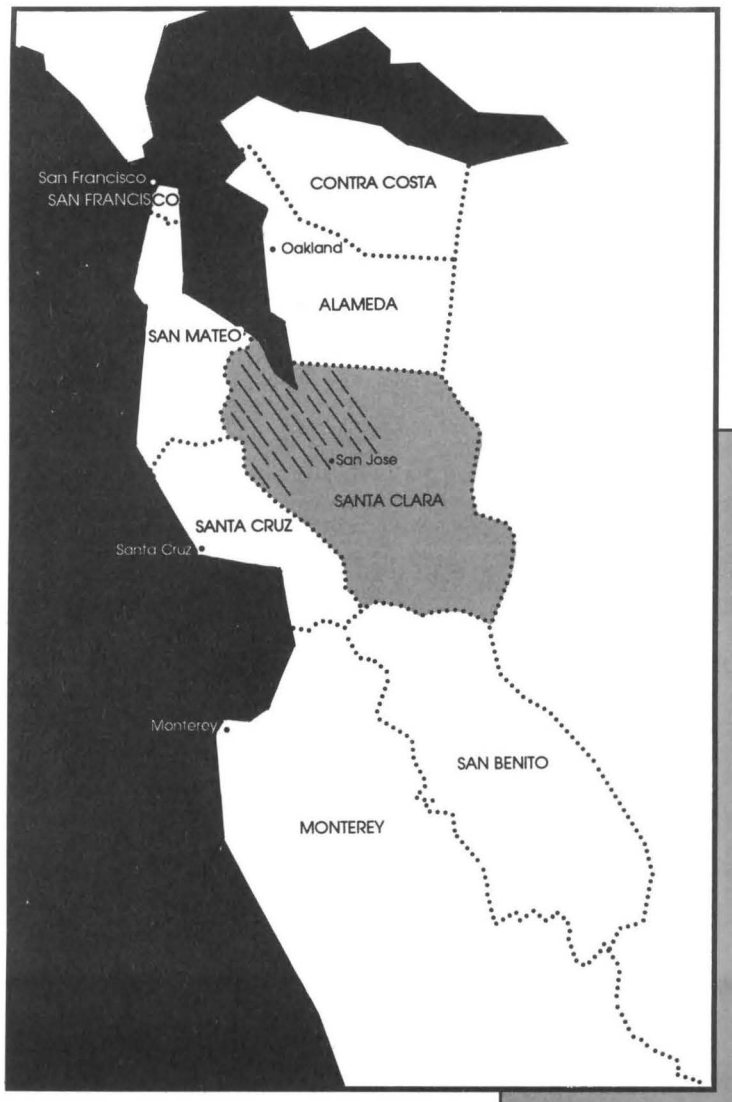
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MEAN ANNUAL PRECIPITATION MAP

for:

San Francisco & Monterey Bay Region

by:
Abdullah D. Saah,
Senior Civil Engineer

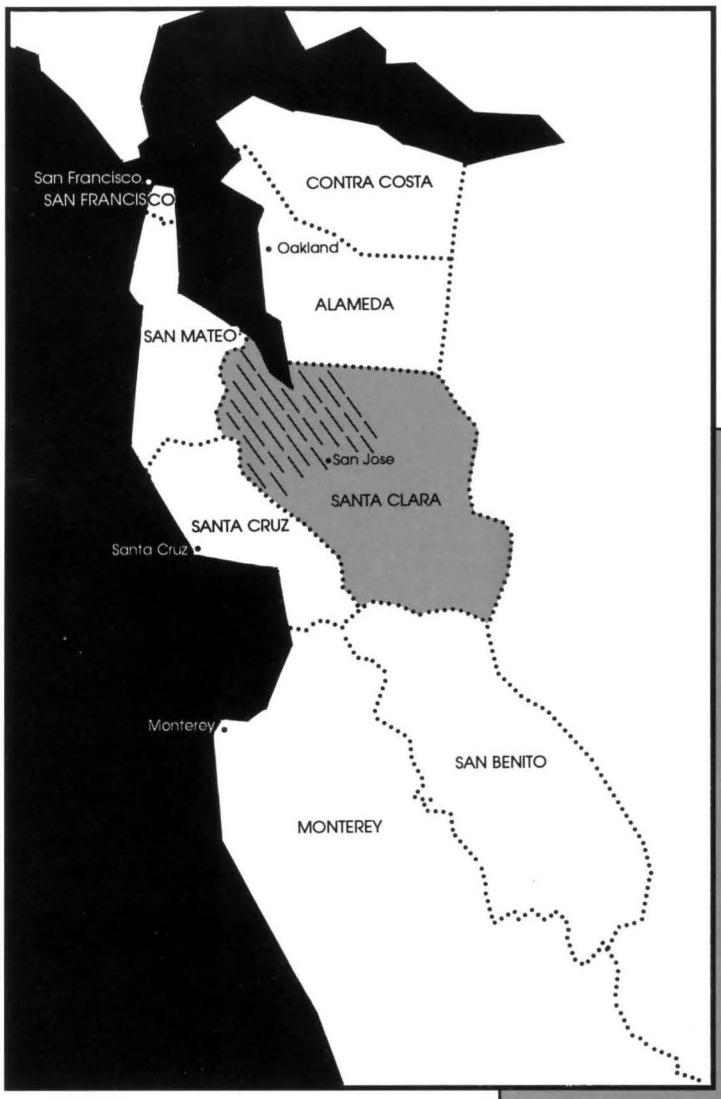
Charles E. Nahn,
Associate Civil Engineer

Santa Clara Valley Water District

October, 1989

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1989
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HYDROLOGY OPEN FILE REPORT



MEAN ANNUAL PRECIPITATION MAP

for:

San Francisco & Monterey Bay Region

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Abdullah D. Saah,
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HYDROLOGY OPEN FILE REPORT

**********NOTE ON USAGE OF MEAN ANNUAL PRECIPITATION MAP**********

This Mean Annual Precipitation Map represents a step towards developing an updated methodology used by the Santa Clara Valley Water District (SCVWD) to generate design peaks and volumes for various creeks and rivers located in and around Santa Clara County. The updated methodology that will utilize these Mean Annual Precipitation values as input modeling parameters is expected to be finalized within the next several years.

The Mean Annual Precipitation values contained in the enclosed map should not be used with any of the previous methodology (e.g. SCVWD regression equations, Santa Clara County Drainage Manual, SCVWD urban hydrology) to generate design peaks and volumes.

SANTA CLARA VALLEY WATER DISTRICT

MEAN ANNUAL PRECIPITATION MAP

FOR

SANTA CLARA AND ADJACENT COUNTIES

BY

Abdullah D. Saah, ***Senior Civil Engineer, Hydrologist***
Charles Nahn, ***Associate Civil Engineer***
Robert Pottorff, ***Assistant Civil Engineer***

October 10, 1989

under the direction of

Stan N. Wolfe
Head, Project Development Branch

Ronald R. Esau
General Manager

Stanley M. Williams
Assistant General Manager

Robert R. Smith
Assistant General Manager

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INTRODUCTION

The Santa Clara Valley Water District (District) has completed a study of the precipitation record for the greater San Francisco Bay and Monterey Bay Areas resulting in an isohyetal map detailing mean annual precipitation (MAP) values through the 1988 water year.

This study updates the previous isohyetal maps drawn by the District, the United States Geologic Survey (USGS) and various other agencies.

The map constitutes the compilation of the long-term mean annual rainfall information in the form of isolines. Such a map is necessary for the determination of parameters used in the District's hydrologic modeling and statistical analyses.

This report summarizes the procedures and methodology used to tabulate, analyze, check, and plot the MAP data.

THE STUDY AREA

The study area covers eight counties surrounding the San Francisco and Monterey Bays. These counties are:

Santa Clara
Contra Costa
Alameda
San Francisco
San Mateo
Santa Cruz
Monterey
San Benito

PHYSICAL SETTING

The topography of the study area is characterized by a series of sub-parallel coastal mountain ranges and intervening large and small valleys. Elevations range from sea level up to 4372 feet at Copernicus Peak in the Diablo Mountain Range and 4941 feet in the Santa Lucia Range in Monterey County.

The primary precipitation mechanism in the Bay Area is orographic lifting of moisture-laden air masses. Evaporation occurs over the Pacific Ocean creating moisture-rich air masses approaching the California coast. As the air masses rise over the coastal mountain ranges, the moisture condenses, causing precipitation to occur. Typically, precipitation amounts reach their maximum at the higher elevations of the coastal ranges and recede with decreasing elevation of the inland valleys. The precipitation amounts increase again as the air masses start to rise over the inland mountains.

The study area exhibits large variations in MAP rates due to orographic conditions and other meterorological factors. These rates range from 10 inches per year in the inland valley areas up to 65 inches per year in the higher coastal mountain areas.

THE DATA

MAP data (through 1988 at some stations) from 255 recording and non-recording precipitation stations were used in this study. These stations break down into 161 main stations and 94 secondary stations. Out of the main stations 11 were not used in the final plotting of the isolines due to more reliable data available at nearby stations. Similarly, 38 of the secondary stations were not used for various reasons relating to questionable data, locations or both.

A list of the stations used in the study is available from the Hydrology Section of the District.

SUMMARY OF PROCEDURES

The main stations within similar hydrologic regions, were combined to form 32 separate groups. Each group contained several stations with long term records and many stations with short term records.

In each group, MAP data from individual precipitation stations were correlated with similar data from all other stations to obtain cross correlation matrices. These correlations were then used to adjust the statistics from each short-record station based on information from other long-record stations. This adjustment of statistics was based on the Two Station Comparison technique described by Beard (Reference #1) and by the Interagency Advisory Committee on Water Data (Reference #2).

To ensure a positive transformation of information in the adjustment, arrays of information content parameters were calculated (Reference #3). Such parameters, when greater than unity, represent a positive transformation of information. In this analysis no parameter of less than unity was observed.

The equivalent years of record for each adjusted statistic, representing the standard error of estimates, were also calculated. The equivalent years were then used to weigh each statistic resulting in the final adopted mean and standard deviation for each station. Such weighted statistics include all the spatial and temporal information within the hydrometeorologic region.

The following steps summarize the procedure used to calculate the final statistics of different stations:

Step 1 — Calculate the recorded mean (M), standard deviation (SD) for each station, and the cross correlation coefficients (R) between stations within the same group;

Step 2 — Calculate the information content (I);

Step 3 — Determine the adjusted means (M) and standard deviations (SD) based on the Two Stations Comparison;

Step 4 — Find the equivalent number of years of record (N) and the weighted mean annual precipitation (final values) and weighted standard deviations;

Step 5 — Plot the results of step 4 on the USGS 15 min. quadrangle base map and plot isolines by interpolation as needed.

Detailed explanations of these procedures are available from the Hydrology Section of the District.

Because MAP is a function of elevation and orientation of the surrounding land, the isolines were carefully drawn to conform to general topographic features particularly in areas of sparse recorded rainfall data. To facilitate this process, each 1000 foot contour line on the base map was outlined with a different color. Streams, lakes and hydrologic divide lines (lines delineating watershed boundaries) were also highlighted.

The end product of this study is an isohyetal map of mean annual precipitation for the eight-county area.

DOUBLE MASS CURVE ANALYSIS

The homogeneity of the long term recorded mean annual precipitation data at the San Jose station (which was considered to be a base station) was checked by constructing a double mass curve. Figure #1 shows the curve for the San Jose station plotted against a seven station combined average. Because there is no apparent change in the slope of the curve, it is concluded that there have been no significant changes in gage location, exposure, or observational procedure (Reference #4) of this station. The data from this station were, therefore, used in each grouping to help in the adjustment of statistics.

COMPARISON WITH OTHER MAPS

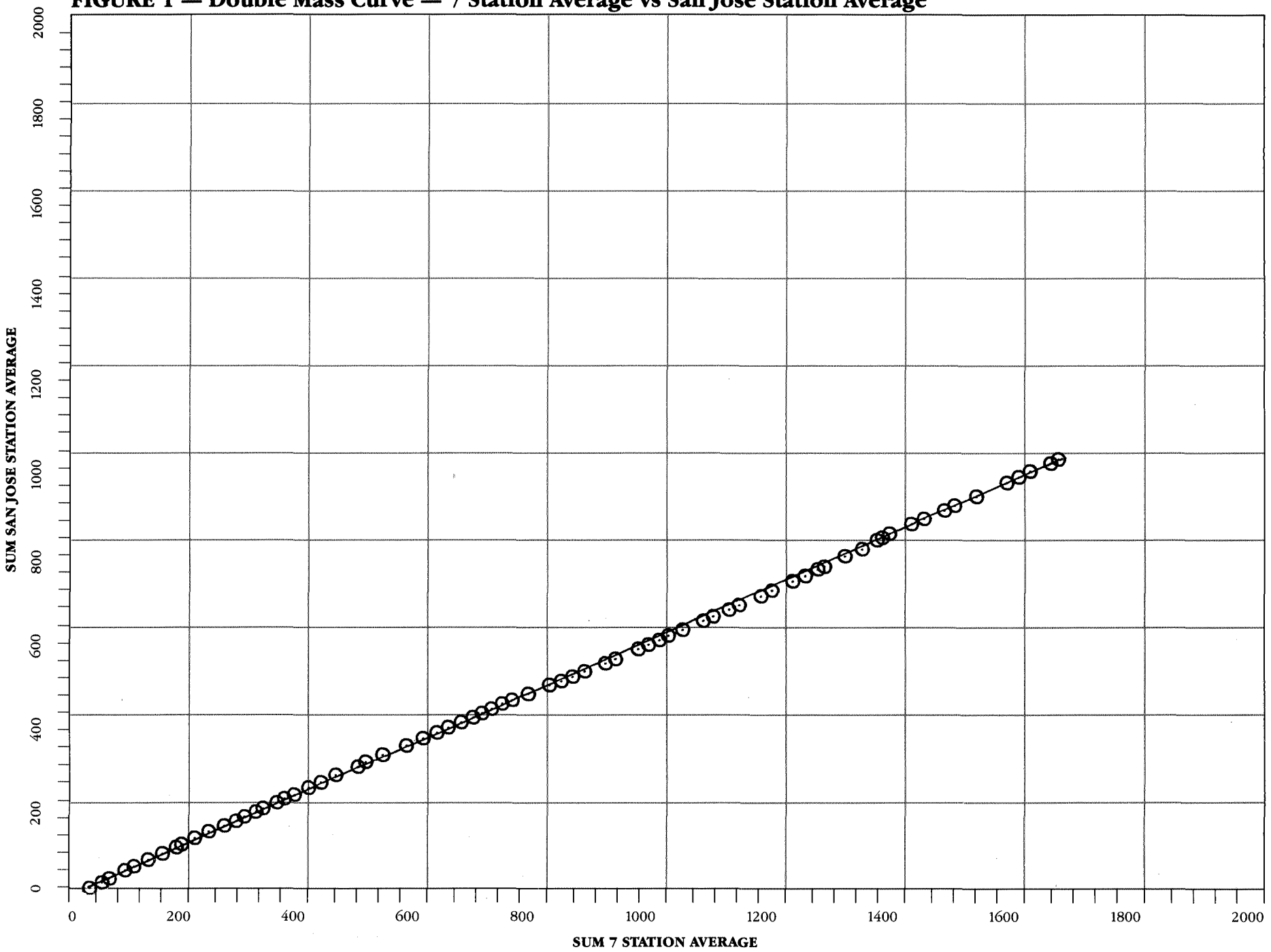
The newly developed map was compared with earlier versions of mean annual precipitation maps, including one prepared in 1972 by the District and others developed by the USGS and Contra Costa and Santa Cruz Counties.

Such comparisons show large deviations in the locations of isolines along the Santa Cruz Mountain range. More site-specific investigations were made in these areas to define the final isolines; thus the new MAP map can be accepted with greater confidence in its precipitation information.

CONCLUSIONS

The use of all available precipitation data through 1988, the correlation of such data, the positive adjustment of statistics, and the weighing of results of such adjustments were steps used in the development of this isohyetal map. These steps insure the accuracy of the map which can serve as a valuable reference for the spatial distribution of long-term precipitation in the region.

FIGURE 1 — Double Mass Curve — 7 Station Average vs San Jose Station Average



ACKNOWLEDGMENTS

Most of the MAP data used in this study were obtained from the Santa Clara Valley Water District, the California Department of Water Resources (DWR), and the National Weather Service (NWS). The East Bay Municipal Utilities District (EBMUD), Contra Costa County Flood Control and Water Conservation District, County of Alameda Public Works Agency, Santa Cruz County Flood Control and Water Conservation District, and San Mateo County Department of Public Works also provided additional MAP data.

This work was closely coordinated with Dr. Baulin Wu of Contra Costa County who provided a preliminary review of the map for this local area. In addition, the map incorporates information from an earlier map prepared for Santa Cruz County by Professor Ray Linsley. The data from Monterey County were provided by Mat Zidar and Gene Taylor who, at the outset of the study, provided valuable information about the distribution of rainfall in the steep mountains of the Santa Lucia Range near Big Sur and Soledad areas. A cursory review of the map was made by James Goodridge (previously the climatologist for the State of California and presently a private consultant).

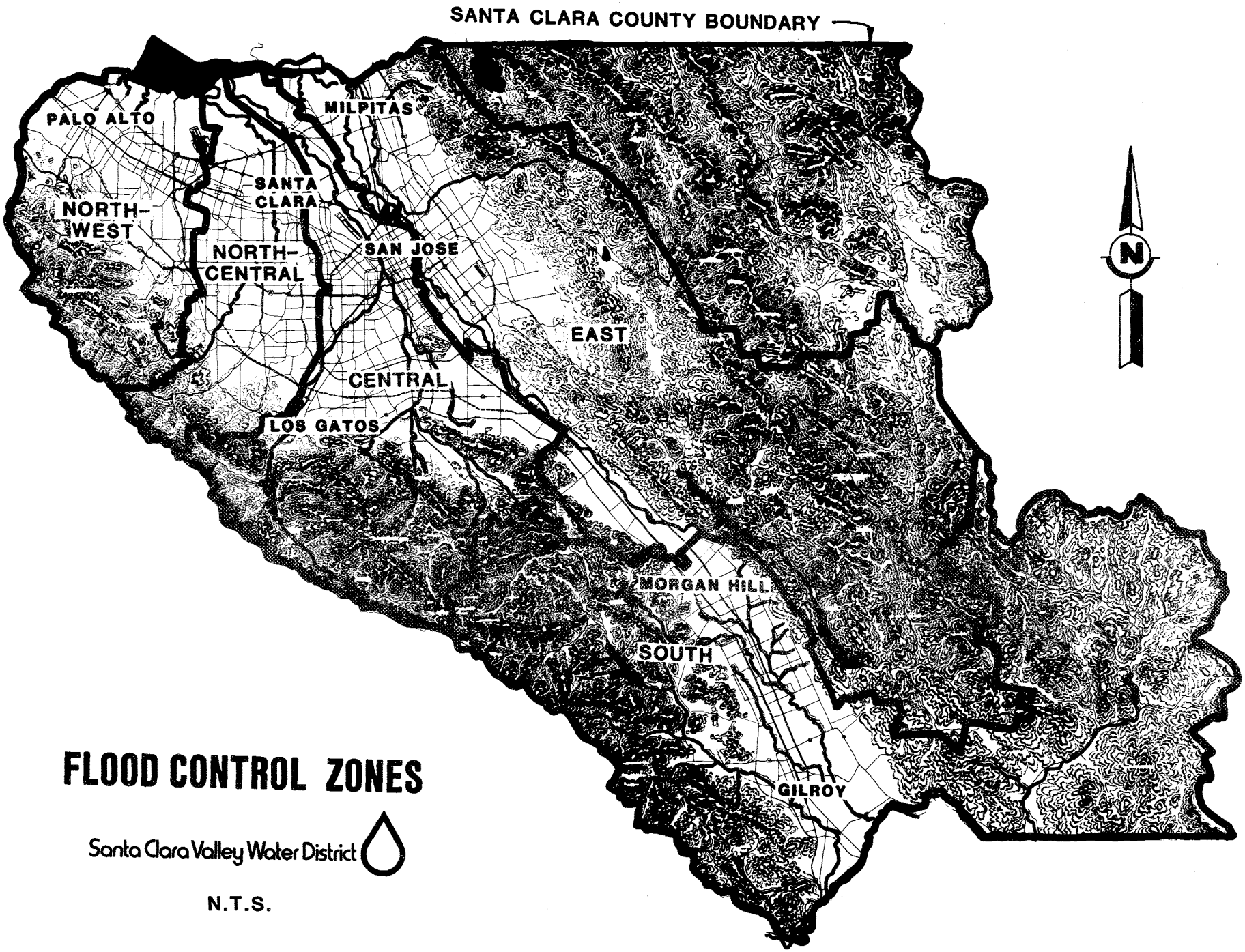
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2. Interagency Advisory Committee on Water Data. 1982. *Guidelines For Determining Flood Flow Frequency; Bulletin #17B of the Hydrology Subcommittee.* Reston, VA: Office of Water Data Coordination, U.S. Geological Survey.

3. Fiering, Myron. 1963. *Use of Correlation to Improve the Estimates of the Mean and Variance; U.S.G.S. Professional Paper #434-C.* Reston, VA: U.S. Geological Survey.

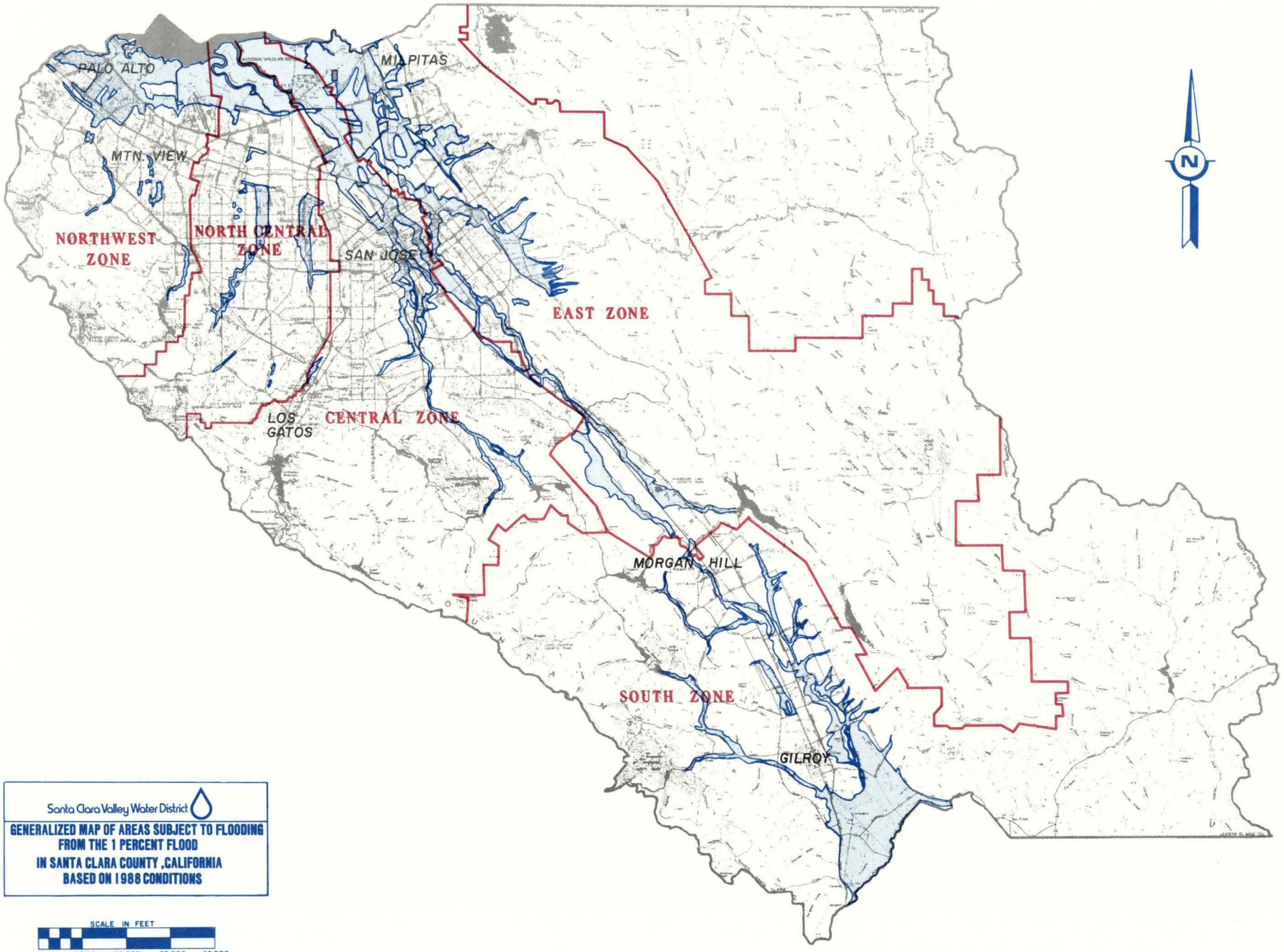
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FLOOD CONTROL ZONES

Santa Clara Valley Water District

N.T.S.

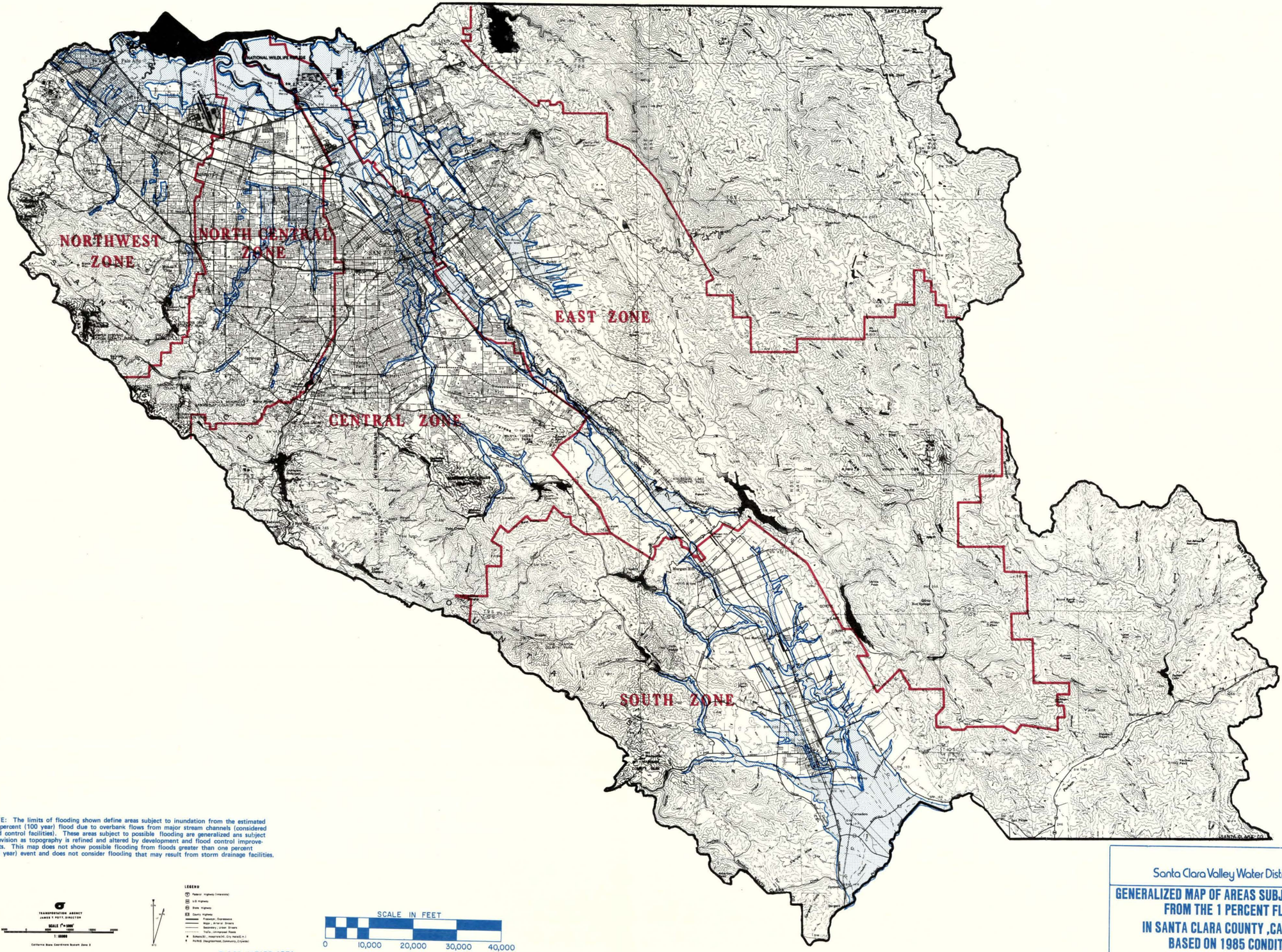


Santa Clara Valley Water District

GENERALIZED MAP OF AREAS SUBJECT TO FLOODING FROM THE 1 PERCENT FLOOD IN SANTA CLARA COUNTY, CALIFORNIA BASED ON 1988 CONDITIONS

SCALE IN FEET

0 10,000 20,000 30,000 40,000



NOTE: The limits of flooding shown define areas subject to inundation from the estimated one percent (100 year) flood due to overbank flows from major stream channels (considered flood control facilities). These areas subject to possible flooding are generalized ans subject to revision as topography is refined and altered by development and flood control improvements. This map does not show possible flooding from floods greater than one percent (100 year) event and does not consider flooding that may result from storm drainage facilities.

TRANSPORTATION AGENCY
JAMES T. PEOT, DIRECTOR

SCALE 1"= 5000'
1 : 60000

California State Coordinate System Zone 3

LEGEND
- Federal Highway (Interstate)
- U.S. Highway
- State Highway
- County Highway
- Freeways, Expressways
- Major, Arterial Streets
- Secondary, Urban Streets
- Traffic, Unimproved Roads
- Railroads(R), Waterways(W), City Halls(C.H.)
- PARKS (Neighborhood, Community, Citywide)

FLOOD HAZARD AREA

SCALE IN FEET
0 10,000 20,000 30,000 40,000

Santa Clara Valley Water District

GENERALIZED MAP OF AREAS SUBJECT TO FLOODING FROM THE 1 PERCENT FLOOD IN SANTA CLARA COUNTY, CALIFORNIA BASED ON 1985 CONDITIONS

SONOMA COUNTY
NAPA COUNTY
LIMIT OF DETAILED STUDY
SOLANO COUNTY
SACRAMENTO COUNTY
CONTRA COSTA COUNTY
SAN JOAQUIN COUNTY
SAN FRANCISCO COUNTY
ALAMEDA COUNTY
SAN MATEO COUNTY
STANISLAUS COUNTY
LIMIT OF DETAILED STUDY
SANTA CLARA COUNTY
SANTA CRUZ COUNTY
SAN BENITO COUNTY
MERCED COUNTY
MADERA COUNTY
FRESNO COUNTY
MONTEREY COUNTY
PACIFIC OCEAN
MONTEREY BAY

LEGEND

(13) = RAINFALL STATIONS WITH MEAN ANNUAL PRECIPITATION

—13"— = ISOLINES WITH MEAN ANNUAL PRECIPITATION

—13"— = ISOLINES CUT OFF AT THIS POINT

DATE	SCALE
12/89	1:250,000
DRAWN	SHEET
BP/FN	1
CHECKED	1 OF 1
CN	

Santa Clara Valley Water District

ENGINEERING CERTIFICATION — ASSOC. CIVIL ENGINEER — R.C.E. NO. 43870

ENGINEERING CERTIFICATION — SENIOR CIVIL ENGINEER — R.C.E. NO. 24084

MEAN ANNUAL PRECIPITATION MAP SAN FRANCISCO & MONTEREY BAY REGION 1988

Scale 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

5 0 5 10 15 Nautical Miles

CONTOUR INTERVAL 200 FEET
DOTTED LINES REPRESENT 100-FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

BATHYMETRIC CONTOUR INTERVALS: 10 METERS TO THE 200 METER DEPTH, 50 METERS TO THE MAXIMUM DEPTH
DATUM: MEAN LOWER LOW WATER

SHORELINE SHOWN REPRESENTS MEAN HIGH WATER

TRANSVERSE MERCATOR PROJECTION

MAGNETIC DECLINATION FROM TRUE NORTH VARIES FROM 16° 20m WEST EASTERLY FOR THE CENTER OF THE WEST EDGE TO 16° 20m WEST EASTERLY FOR THE CENTER OF THE EAST EDGE

FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092
OR NATIONAL OCEAN SURVEY, ROCKVILLE, MARYLAND 20852

N

Mapped, edited, and published by the Geological Survey
Data from a special study financed in part by the Department of Housing and Urban Development
Compiled in 1970 from USGS quadrangles dated 1949–1967
Limited revision from aerial photographs taken April-May 1970 and from available boundary and airport information
Selected hydrographic data compiled from USC&GS charts and hydrographic surveys. This information not intended for navigational purposes
Lambert Conformal Conic projection. 1927 North American datum
50,000-foot grid based on California coordinate system, zone 2
5000-meter Universal Transverse Mercator grid ticks, zone 10, shown in blue